X-520-62-86

STAR CATALOGS ON PUNCHED CARDS AND MAGNETIC TAPES—DETAILS

BY

J. H. BERBERT

AND

J. D. OOSTERHOUT

JUNE 1962

GODDARD SPACE FLIGHT CENTER

GREENBELT, MD.

STAR CATALOGS ON PUNCHED CARDS AND MAGNETIC TAPE - DETAILS

National Aeronautics and Space Administration Technical Note D-1153 announced that the Goddard Space Flight Center has in its possession a Punched Card Star Catalog containing information combined from the AGK_2, the Yale Zone, and the Cape Photographic Star Catalogs. It was also made known that this information had been transcribed onto magnetic tape and that copies of either the cards or tape would be provided to qualified organizations in exchange for an equivalent number of new tapes or cards. With this announcement there was an account of the contents and format of the Punched Card Star Catalog but some details were omitted. This Memo is designed to supply those details and, additionally, to answer as many questions regarding this catalog and its applications as can be anticipated.

The transcription of catalog information onto punched cards was done by the United States Naval Observatory and the Yale University Observatory with funding from NASA. The cards punched by each group were checked by the other for transcription errors. The precession terms, where given, were recalculated.

Of the modern star catalogs the AGK_2, the Yale Zone and the Cape Photographic were chosen because they cover stars up to the ninth and tenth magnitudes. The Yale Zone overlaps both the other catalogs. In all the overlapping regions the Yale Zone Catalog was chosen to the exclusion of the other catalogs. It was felt that the Yale Zone was more accurate than the Cape Photographic and it gives proper motion values whereas the AGK_2 does not.

The star catalog on punched cards blankets the sky from the north pole to -64° declination. This is as far south as the Cape Catalog goes. Magnitudes (photographic) covered by the approximately 300,000 stars of the Punched Card Catalog range generally from 5 to 11. Brighter stars appear but many are omitted, presumably because their photographic images were too large for accurate measurements. Five hundred is a rough estimate of the number of missing stars. Since there exist catalogs that give complete coverage to the lower magnitudes, it is hoped that, before long, the Punched Card Catalog will include all the brighter stars. The following charts give an idea of the number of stars of each magnitude.

Questions have been asked about the accuracy of this Punched Card Catalog. The answer is that they are as accurate as the catalogs from which they are transcribed. The best work on the accuracies of the catalogs is contained in their prefaces. Dr. Francis P. Scott of the U.S. Naval Observatory, who has been our authority in these matters, gives

NUMBER OF STARS BRIGHTER THAN A GIVEN MAGNITUDE (REF. 1)

Magnitude Limit	Number of Stars	
	Photographic	Visual
4.0	360	530
5.0	1,030	1,620
6.0	2,940	4,850
7.0	8,200	14,300
8.0	22,800	41,000
9.0	62,000	117,000
10.0	166,000	324,000
11.0	431,000	870,000
12.0	1,100,000	2,270,000

0."2 to over 0."8 as a range in error for a star updated to the epoch 1962.5 when the available proper motion values are used. Systematic errors in determining the proper motion values might double these figures. In updating without proper motion the range in error is from 0."7 to over 3."0.

Tables 1 and 2 presented in NASA Technical Note D-1153 give a list equating the Naval Observatory volume numbers with the original catalogs in Table 1 and the punched card format for each star in Table 2. They are repeated here for convenience.

The following is a list of exceptions, omissions and other particulars bearing on these punched cards. One thing to note is the treatment of the plus and minus signs. To get everything on the cards it was necessary to punch each sign above the least significant digit in its respective field. A punch in the y, or top, row is a plus and in the x, or next to the top, row is a minus.

Also to be regarded is the treatment of the epoch at which the given star was photographed. If the epoch is, for example, 1934.34, this is punched as 34.34. If it is 1898.60, it is punched -01.40.

I. The AGK_2 Catalog

U.S. Naval Observatory Catalog Number	AGK Catalog Number	Declination in 10 Bands
01	AGK_2 1	+70° to +90°
02	2	+60° to +70°
05	5	+45° to +50°
06	6	+40° to +45°
07	7	+35° to +40°
08	8	+30° to +35°

Table 1

Star Catalogs on Punched Cards and Magnetic Tape

Naval Observatory Number	Catalog Number	Declination (degrees)
01	AGK2 1	+70 to +90
02	AGK2 2	+60 to +70
03	Yale 27	+55 to +60
04	Yale 26II	+50 to +55
05	AGK2 5	+45 to +50
06	AGK2 6	+40 to +45
07	AGK2 7	+35 to +40
08	AGK2 8	+30 to +35
09	Yale 24	+25 to +30
10	Yale 25	+20 to +25
11	Yale 18	+15 to +20
12	Yale 19	+10 to +15
13	Yale 22II	+ 9 to +10
14	Yale 22I	+ 5 to + 9
15	Yale 20	+ 1 to + 5
16	Yale 21	+ 1 to - 2
17	Yale 17	- 2 to - 6
18	Yale 16	- 6 to -10
19	Yale 11	-10 to -14
20	Yale 12I	-14 to -18
21	Yale 12II	-18 to -20
22	Yale 13I	-20 to -22
23	Yale 14	-22 to -27
24	Yale 13II	-27 to -30
25	Cape	-30 to -35
26	Cape	-35 to -40
*27	Cape	-40 to -52
28	Cape	-52 to -56
29	Cape	-56 to -60
30	Cape	-60 to -64

*Updated to the equinox 1950.0 to match the other catalogs.

Table 2
Format on IBM Cards for Star Data

IBM CARD COLUMN NO.	DESCRIPTION
1 ±	EPOCH
5	CATALOGUE STAR NO.
10	VIS. MAG.
14	PHOTOG. MAG.
18	SPECT. TYPE
21 ±	COLOR INDEX
24 _____h _____m _____. s 32	RIGHT ASCENSION 1950.0
33 _____. s/cent. 38 ±	I PREC. IN R.A.
39 _____. s/cent.^{2} ±	II 1/2 SECULAR VAR. IN R.A.
43 ±	III IN R.A.
46 ± "/yr.	PROP. MOTION IN R.A.
50 _____deg. _____' _____." 57 ±	DECLINATION 1950.0
58 "/cent. 62 ±	I PREC. IN DECL.
63 _____. "/cent.^{2} ±	II 1/2 SECULAR VAR. IN DECL.
66 ±	III IN DECL.
68 _____. "/yr. ±	PROP. MOTION IN DECL.
72 _____. 78 ±	B.D., C.D., or C.P.D. NO.
80	VOL. NO.

Epoch, right ascension, declination and star number have been punched for each star, and photographic magnitude and BD number when given. All other columns are blank. This means the I and II precession terms are absent. Anyone using these punched card catalogs would have access to a computer, in which case he would undoubtedly prefer to program the exact precession equations for star updating. The following equations and table are taken from Reference II.

1. $a = \alpha_o - z$,
2. $\sin \delta = \cos \theta \sin \delta_o - \sin \theta \cos \delta_o \cos a$,
3. $\cos \delta \cos a' = \cos \theta \cos \delta_o \cos a + \sin \theta \sin \delta_o$,
4. $\cos \delta \sin a' = \cos \delta_o \sin a$
5. $\alpha = a' - \zeta_o$.

(Notice that z and ζ_o are given in seconds of time.) Equations 2, 3 and 4 are not independent of each other. Nevertheless, all three are supplied for whatever juggling a programmer might want to do in the delicate situation where δ is near 90°.

EQUATORIAL PRECESSIONAL ELEMENTS

Date	ζ_o	z	$\sin \theta$	$\cos \theta$
1900	+76.814	+76.827	+0.004 85892	+0.999 98820
1910	61.454	61.462	0.003 88707	0.999 99244
1920	46.092	46.097	0.002 91525	0.999 99575
1930	30.730	30.732	0.001 94346	0.999 99811
1940	+15.366	+15.366	+0.000 97171	0.999 99953
1950	0.000	0.000	0.000 00000	+1.000 00000
1951	-1.537	-1.537	-0.000 09717	1.000 00000
1952	3.073	3.073	0.000 19434	0.999 99998
1953	4.610	4.610	0.000 29151	0.999 99996
1954	6.147	6.147	0.000 38867	0.999 99992
1955	-7.683	-7.683	-0.000 48584	+0.999 99988
1956	9.220	9.220	0.000 58301	0.999 99983
1957	10.757	10.757	0.000 68017	0.999 99977
1958	12.294	12.293	0.000 77734	0.999 99970
1959	13.830	13.830	0.000 87450	0.999 99962
1960	-15.367	-15.367	-0.000 97167	+0.999 99953
1961	16.904	16.903	0.001 06883	0.999 99943
1962	18.441	18.440	0.001 16600	0.999 99932
1963	19.977	19.977	0.001 26316	0.999 99920
1964	21.514	21.513	0.001 36032	0.999 99907
1965	-23.051	-23.050	-0.001 45749	+0.999 99894
1966	24.588	24.587	0.001 55465	0.999 99879
1967	26.125	26.123	0.001 65181	0.999 99863
1968	27.662	27.660	0.001 74897	0.999 99847
1969	29.199	29.197	0.001 84613	0.999 99829
1970	-30.736	-30.733	-0.001 94330	+0.999 99811
1971	32.273	32.270	0.002 04046	0.999 99792
1972	33.809	33.807	0.002 13762	0.999 99771
1973	35.346	35.344	0.002 23477	0.999 99750
1974	36.883	36.880	0.002 33193	0.999 99728

EQUATORIAL PRECESSIONAL ELEMENTS (CONTINUED)

Date	ζ_o	z	sin θ	cos θ
1975	-38.420	-38.417	-0.002 42909	+0.999 99705
1976	39.957	39.954	0.002 52625	0.999 99681
1977	41.494	41.491	0.002 62341	0.999 99656
1978	43.031	43.027	0.002 72056	0.999 99630
1979	44.568	44.564	0.002 81772	0.999 99603
1980	-46.106	-46.101	-0.002 91488	+0.999 99576

II. The Cape Photographic Catalog

U.S. Naval Observatory Catalog Number	Cape Catalog Number
25	Cape -30 -- -35
26	Cape -35 -- -40
27	Cape -40 -- -52
28	Cape -52 -- -56
29	Cape -56 -- -60
30	Cape -60 -- -64

Cols. 1 -- 32, 46 -- 57, 68 -- 80, are punched if values are given in catalogs, otherwise these columns are blank. All other columns are always blank.

Col. 10-13, Variable stars punched.

Spectral Types, Col. 18-19-20.

Col. 18	Col. 19	Col. 20
R 0	0 or a 0	
0e5,0e4 1	1 or b 1	
O 2	2 or c 2	
B 3	3 or d 3	* 3
A 4	4 or e 4	
F 5	5 5	g 5
G 6	6 6	
K 7	7 7	
M 8	8 8	
N 9	9 9	
S x		p x
Blank y	Blank y	Blank y

PEC punched yyx

Composite stars punched 3 in column 20.

Vol. 27

Cape -40 -- -52(1900.0) was reduced to 1950.0 by the rigorous formulae given on page 108 of Planetary Co-ordinates for the Years 1960-1980. (Ref. No. 2). Proper Motion has not been applied to these positions.

Vol. 28

Cape -52 -- -56 Star 2125 Visual Mag. -00.90

Vol. 30

Cape -60 -- -64 Star 4368 Visual Mag. -00.25

} Exceptions

III. Yale Catalog

There are two distinct groups of Yale Catalogs. Yale 27 and Yale 26II are newer than the others and have certain differences.

U.S. Naval Observatory Catalog Number	Yale Catalog	Declination
03	Yale 27	+55° to +60°
04	Yale 26II	+50° to +55°

The fields allotted to the color index and the III terms, i.e. the third coefficient in the series expansions for precession, are blank. Fields which are completely blank in the catalog will be blank on the card; except for visual magnitude which is "K" in the catalogs and is punched on the cards.

Col. 18-19-20. Spectral type is given in the same code as for the Cape Catalogs, except for changes noted below.

Col. 18	Col. 19	Col. 20
R 0	0 0	b 1
W 1	1 1	e 2
O 2	2 2	I 3
B 3	3 3	
A 4	4 4	
F 5	5 5	
G 6	6 6	
K 7	7 7	
M 8	8 8	
N 9	9 9	
S x		p x
Blank y	Blank y	Blank y

Slightly different rules apply to the following volumes.

U.S. Naval Observatory Catalog Number	Yale Catalog	Declination
09	24	+25° to +30°
10	25	+20° to +25°
11	18	+15° to +20°
12	19	+10° to +15°
13	22 Pt. II	+ 9° to +10°
14	22 Pt. I	+ 5° to + 9°
15	20	+ 1° to + 5°

U.S. Naval Observatory Catalog Number	Yale Catalog	Declination
16	21	+ 1° to - 2°
17	17	- 2° to - 6°
18	16	- 6° to -10°
19	11	-10° to -14°
20	12 Pt. I	-14° to -18
21	12 Pt. II	-18° to -20°
22	13 Pt. I	-20° to -22°
23	14	-22° to -27
24	13 Pt. II	-27 to -30

Col. 10-13 Visual Magnitude

10 punched 0

13 punched 0

11, 12 punched xx for variable stars

11, 12 punched yy for stars fainter than 9.9

Spectral Types; Col. 18-19-20

Col. 18	Col. 19	Col. 20
R 0	0 or a 0	c 0
0e5 1	1 or b 1	v 1
O 2	2 or c 2	e 2
B 3	3 or d 3	* 3
A 4	4 or e 4	m or n 4
F 5	5 5	note or g 5
G 6	6 6	*p 6
K 7	7 7	ep 7
M 8	8 8	cp 8
N 9	9 9	cv 9
S x	p x	p x
Blank y	Blank y	Blank y

Color Index Col. 21-23 always blank

III α Col. 43-45 always blank

III α Col. 66-67 always blank

In these Volumes all other blanks in the Catalog are punched y.

Further Remarks

The 1950.0 positions do not include proper motion correction in any of the catalogs. In all cases proper motion is given in seconds of arc per annum. This is true of right ascension as well as declination. To apply the proper motion correction, the epoch of the original photographic plate from which the star's position was computed, is subtracted from that of the later epoch of interest and the difference is multiplied by the proper motion value. This result is added to the precessed star position. It should be noted further that the values given for proper motion in right ascension have already taken account of the star's declination, i.e., do not multiply by the secant of declination.

Binary stars will present a problem to anyone using the B.D., C.D. or C.P.D. numbers to identify them. Confronted with one B.D. number for two stars, the modern catalogs appended letters to this number to differentiate the stars. To conserve space it was necessary to omit these letters when punching in the B.D. numbers.

One serious difficulty for users of this punched card catalog is encountered at the boundary points between the Yale Zone Catalog and the other two catalogs and between one Yale Catalog and another. Unfortunately there is some overlap at the seams and the same star will appear twice. How often this is the case has not been ascertained. No effort has yet been made to eradicate this duplication.

The Star Catalog on Tape

The Punched Card Catalog has been transcribed onto magnetic tape in several different forms. The two sets being made available to users are: 1) 16 low density tapes with one record gap per star, 2) 4 high density tapes with one "record gap" per ten stars. Both these sets are in the binary coded decimal form. Set 1 has 92 characters per star – the 80 characters on the IBM card expanded to 92 on tape when the plus and minus signs were placed in front of the most significant digits in their respective fields. Thus in set 1 there are 92 characters per record. However, in set 2 there are 960 characters per record as will be explained.

Allowing for the different treatment of the signs, the magnetic tape contains a direct transmission of the cards. The format for the tape is indicated in Figure 1.

Note in Figure 1 that there are heading cards transcribed onto the tapes showing the number "50" and giving the range of declination for each declination grouping. Each tape begins with such a card and there are usually several such on a single tape. In the format indicated, there is another special set of characters at the end of each tape showing the number "51". The "50" and "51" card information is surrounded on tape, in each case, by record gaps.

Changes in the Compressed Master Tapes

A few alterations have been made in going from the set of 16 to the compressed set of four tapes. In the fields for proper motion (μ_α and μ_δ) and for B.D. numbers wherever 12 punches (+ or y) were previously used to indicate blanks, these punches have been replaced with blanks. At the end of each star entry four blanks have been added to the original set of 92 characters. This was called for by a computer peculiarity. Thus each star on the compressed tapes is represented by 96 characters and a record by 960 characters. On these compressed master tapes there is no "51" record at the end of the tapes. There is, however, an end of file mark. When the last record of a declination group does not contain ten stars, blanks are used to fill in the additional spaces so that all star records are of equal length. The index to the 16 tapes is:

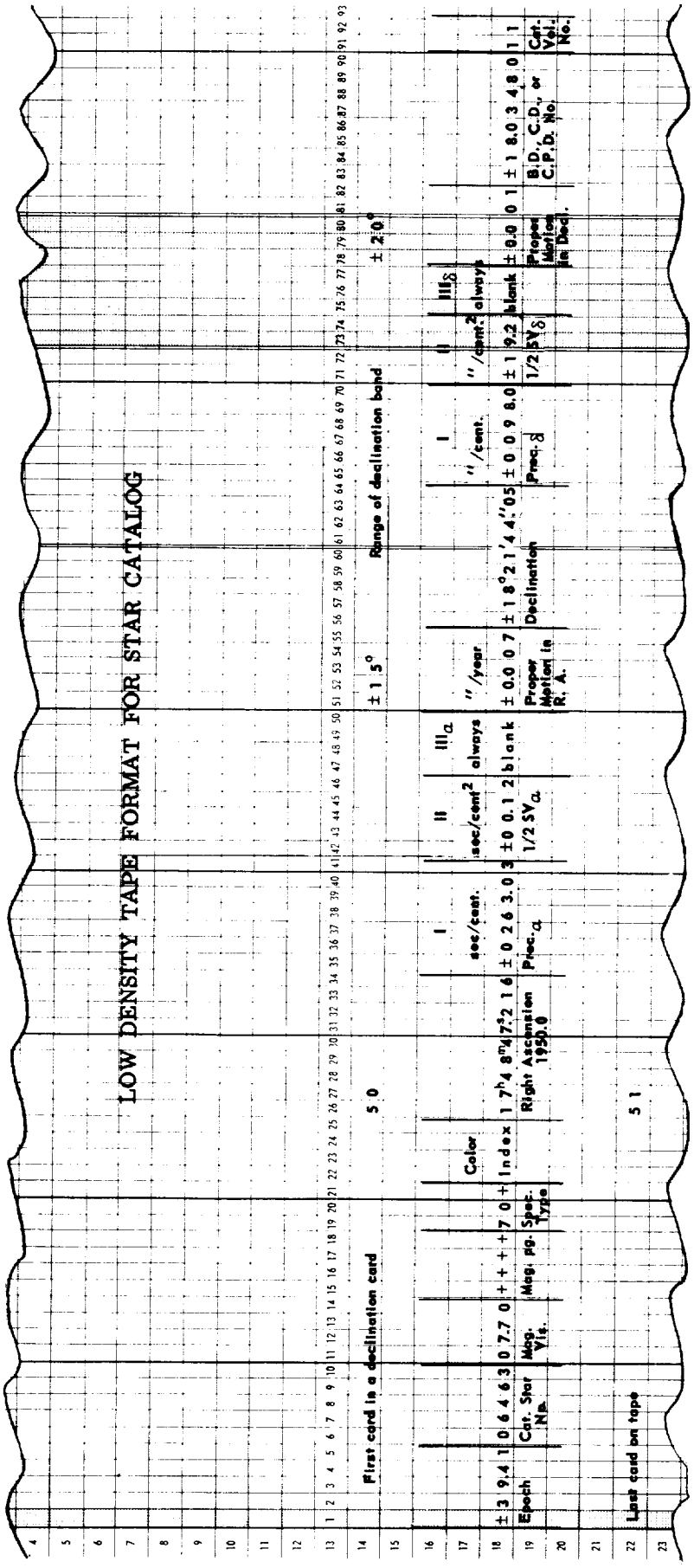

Figure 1. Tape Format

INDEX TO STAR CATALOG TAPES

Tape Sequence	Star Catalog	Naval Observatory Cat. No.	Range in Declination (From -64° to +90°) (Degrees)	Initial Declination on Tape (Degrees)
1	AGK2 1 AGK2 2(beg.)	01 02(beg.)	(+63) - (+90) (in 1° bands)	(+89) - (+90)
2	AGK2 2(end) YALE 27 YALE 26II	02(end) 03 04	(+62) - (+63) (+55) - (+60) (+61) - (+62) (+50) - (+55) (+60) - (+61)	(+62) - (+63)
3	AGK2 5 AGK2 6	05 06	(+40) - (+50) (in 1° bands)	(+49) - (+50)
4	AGK2 7 AGK2 8(beg.)	07 08(beg.)	(+32) - (+40) (in 1° bands)	(+39) - (+40)
5	AGK2 8(end) YALE 24	08(end) 09	(+31) - (+32) (+30) - (+31) (+25) - (+30)	(+31) - (+32)
6	YALE 25 YALE 18	10 11	(+20) - (+25) (+15) - (+20)	(+20) - (+25)
7	YALE 19 YALE 22II YALE 22I	12 13 14	(+10) - (+15) (+09) - (+10) (+05) - (+09)	(+10) - (+15)
8	YALE 20 YALE 21 YALE 17	15 16 17	(+01) - (+05) (-02) - (+01) (-06) - (-02)	(+01) - (+05)
9	YALE 16 YALE 11	18 19	(-10) - (-06) (-14) - (-10)	(-10) - (-06)
10	YALE 12I YALE 12II YALE 13I	20 21 22	(-18) - (-14) (-20) - (-18) (-22) - (-20)	(-18) - (-14)
11	YALE 14	23	(-27) - (-22)	(-27) - (-22)
12	YALE 13II CAPE	24 25	(-30) - (-27) (-35) - (-30)	(-30) - (-27)
13	CAPE	26	(-40) - (-35)	(-40) - (-35)
14	CAPE	27	(-52) - (-40)	(-52) - (-40)
15	CAPE	28	(-56) - (-52)	(-56) - (-52)
16	CAPE	29 30	(-60) - (-56) (-64) - (-60)	(-60) - (-56)

The range in declination covered by each of the compressed Master Tapes is as follows:

	Declination
Tape 1	(+32) - (+90)
Tape 2	(-06) - (+32)
Tape 3	(-35) - (-06)
Tape 4	(-64) - (-35)

(The Master Tapes have been copied in the order from No. 1 to No. 16 so that the declination range indicated above does not give the exact order in which the stars appear on each compressed tape, but rather the overall declination range covered by the tape.)

By using a special print program for the IBM-1401, these tapes can be listed. They may also be copied onto other tapes with the 1401.

REFERENCES

1. Russell-Dugan-Stewart, Astronomy, Vol. II, Ginn and Company, 1938.

2. Planetary Coordinates, 1960-1980, British Nautical Almanac Office.